Renewable Energy in Texas

"Renewable Solutions for Energy Prosperity in Texas"
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AT&T Conference Center
The University of Texas at Austin

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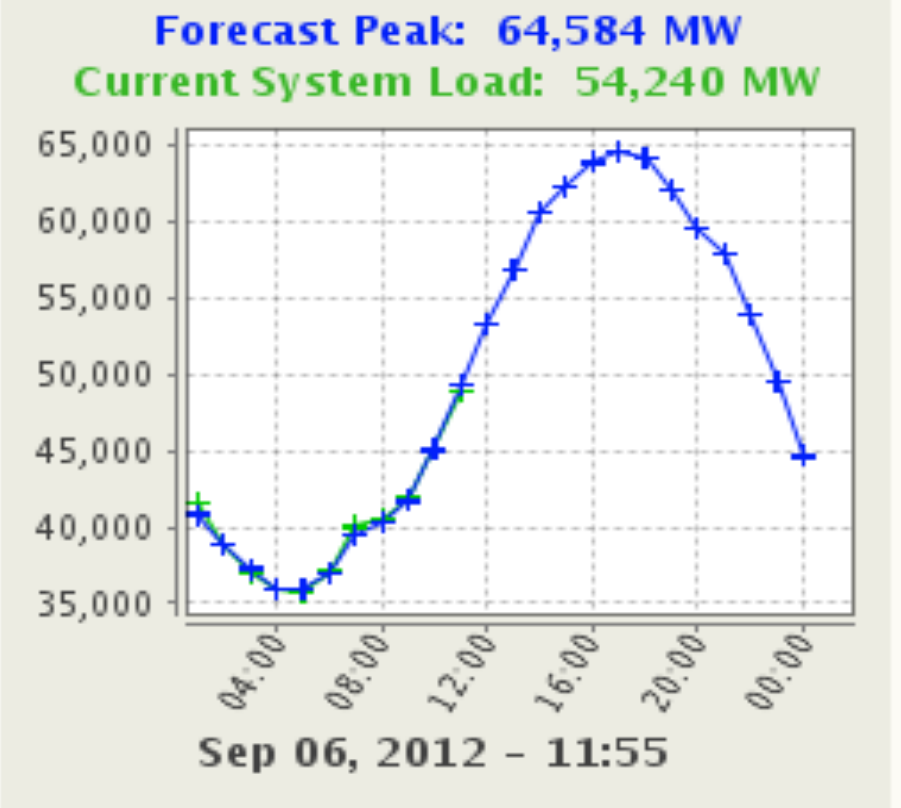
“The Electric Reliability Council of Texas (ERCOT) manages the flow of electric power to 23 million Texas customers - representing 85 percent of the state's electric load. As the independent system operator for the region, ERCOT schedules power on an electric grid that connects 40,500 miles of transmission lines and more than 550 generation units.”



What are our renewable resources, and how do they "fit" with ERCOT's needs?

- New report: "U.S. Renewable Energy Technical Potentials: A GIS-Based Analysis," A. Lopez, B. Roberts, D. Heimiller, N. Blair, and G. Porro, NREL/TP-6A20-51946 (July, 2012)
- "Represents the achievable energy generation of a particular technology given system performance, topographic limitations, environmental, and land-use constraints…an upper-boundary estimate of development potential."
- The "analysis does not allocate land for use by a particular technology, the same land area may be the basis for estimates of multiple technologies."
- Hence, the following gives Texas the opportunity to optimize land use for renewable energy sources.

"U.S. Renewable Energy Technical Potentials: A GIS-Based Analysis"
A. Lopez, B. Roberts, D. Heimiller, N. Blair, and G. Porro, NREL/TP-6A20-51946 (July, 2012)

Estimated total potential for urban utility-scale photovoltaics

U.S. Total:	25,369 KM^2	1,218 GW	2,231,694 GWh
Texas:	3,214 KM^2	154 GW	294,684 GWh

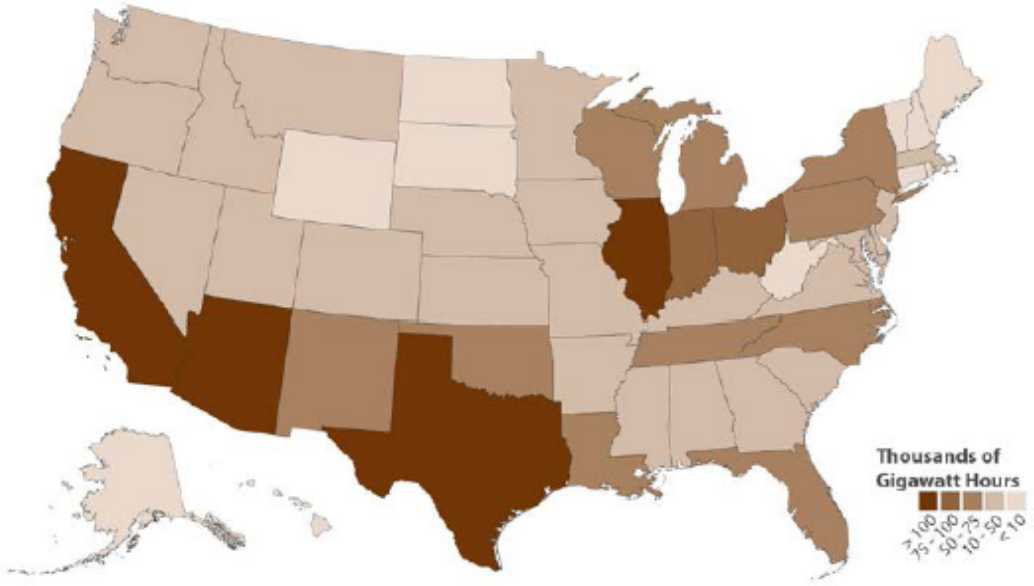


Figure 2. Total estimated technical potential for urban utility-scale photovoltaics in the United States

"U.S. Renewable Energy Technical Potentials: A GIS-Based Analysis"
A. Lopez, B. Roberts, D. Heimiller, N. Blair, and G. Porro, NREL/TP-6A20-51946 (July, 2012)

Estimated total potential for rural utility-scale photovoltaics

U.S. Total:	3,186.955 KM^2	152,974 GW	280,613,217 GWh
Texas:	425,230 KM^2	20,411 GW	39,993,582 GWh

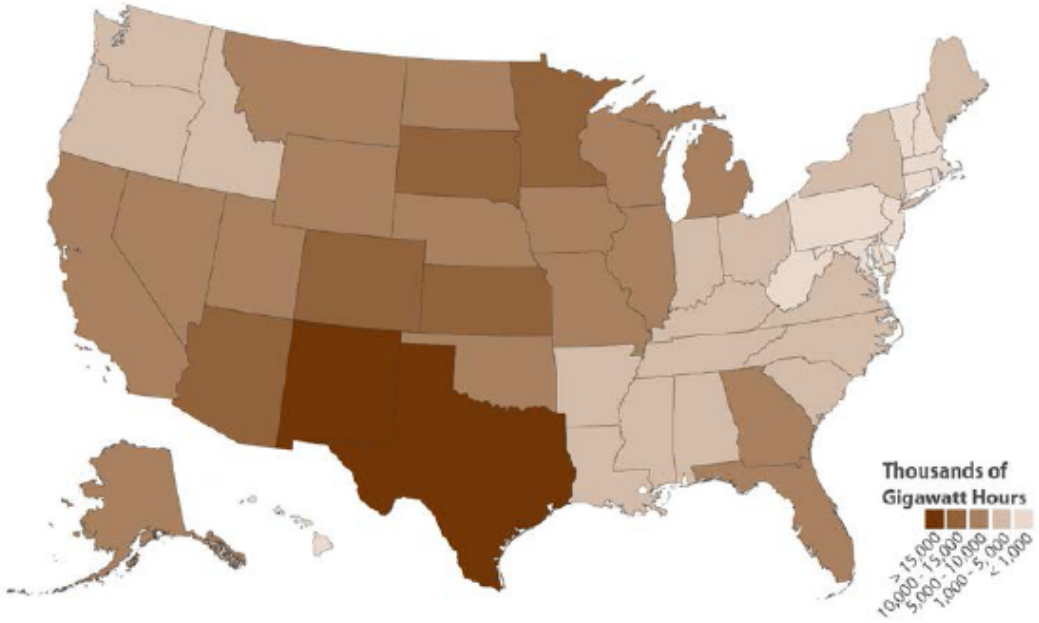


Figure 3. Total estimated technical potential for rural utility-scale photovoltaics in the United States

"U.S. Renewable Energy Technical Potentials: A GIS-Based Analysis"
A. Lopez, B. Roberts, D. Heimiller, N. Blair, and G. Porro, NREL/TP-6A20-51946 (July, 2012)

Estimated total potential for rooftop photovoltaics

U.S. Total:	664 GW	818,733 GWh
Texas:	60 GW	78,717 GWh

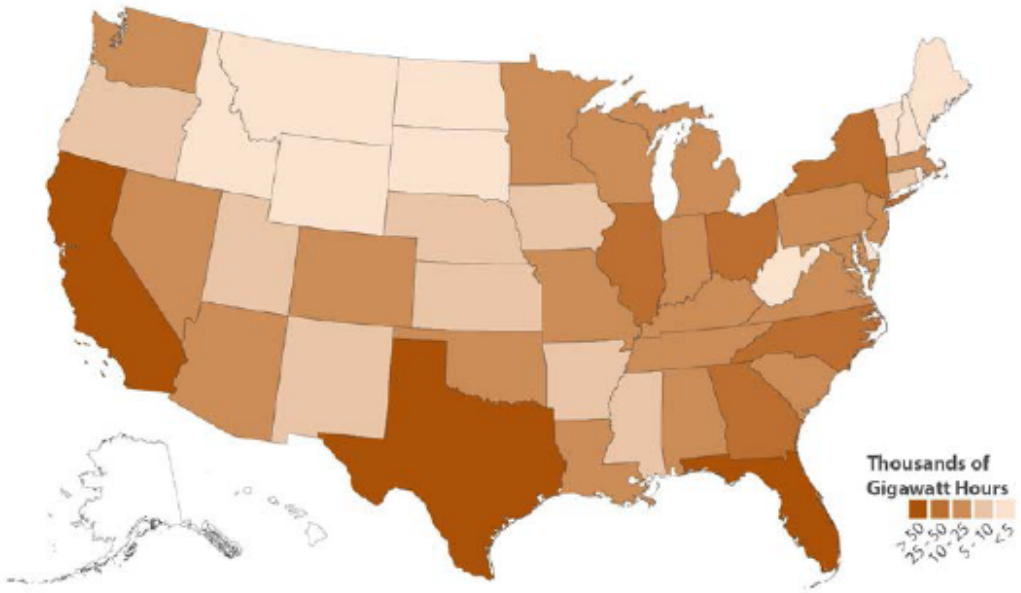


Figure 4. Total estimated technical potential for rooftop photovoltaics in the United States

"U.S. Renewable Energy Technical Potentials: A GIS-Based Analysis"
A. Lopez, B. Roberts, D. Heimiller, N. Blair, and G. Porro, NREL/TP-6A20-51946 (July, 2012)

Estimated total potential for concentrating solar power

U.S. Total:	1,157,209 KM^2	38,066 GW	116,146,245 GWh
Texas:	235,398 KM^2	7,743 GW	22,786,750 GWh

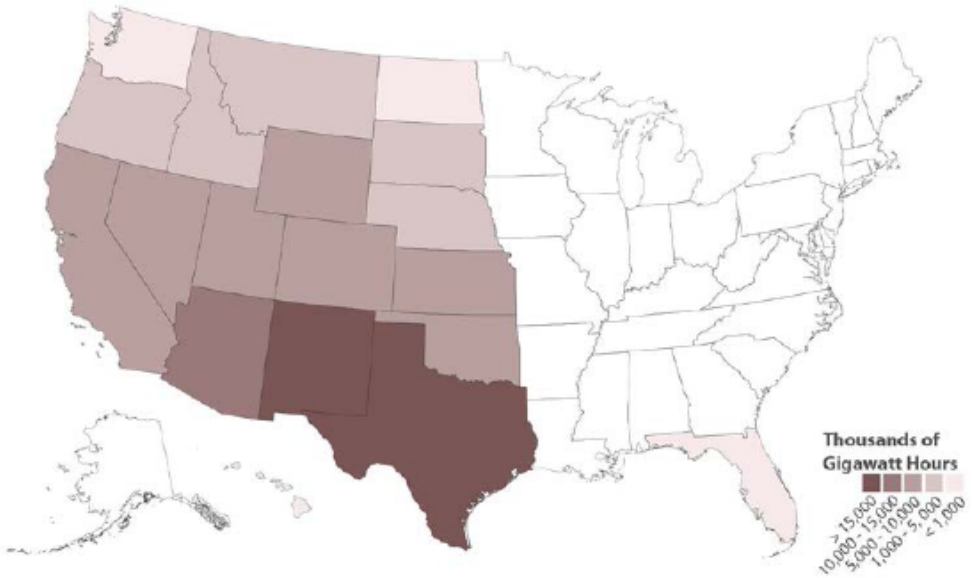


Figure 5. Total estimated technical potential for concentrating solar power in the United States

"U.S. Renewable Energy Technical Potentials: A GIS-Based Analysis"
A. Lopez, B. Roberts, D. Heimiller, N. Blair, and G. Porro, NREL/TP-6A20-51946 (July, 2012)

Estimated total potential for onshore wind power

U.S. Total:	2,190,952 KM^2	10,955 GW	32,784,004 GWh
Texas:	380,306 KM^2	1,902 GW	5,552,400 GWh

Figure 6. Total estimated technical potential for onshore wind power in the United States

"U.S. Renewable Energy Technical Potentials: A GIS-Based Analysis"
A. Lopez, B. Roberts, D. Heimiller, N. Blair, and G. Porro, NREL/TP-6A20-51946 (July, 2012)

Estimated total potential for offshore wind power

U.S. Total:	844,703 KM^2	4,223 GW	16,975,802 GWh
Texas:	54,289 KM^2	271 GW	1,101,063 GWh

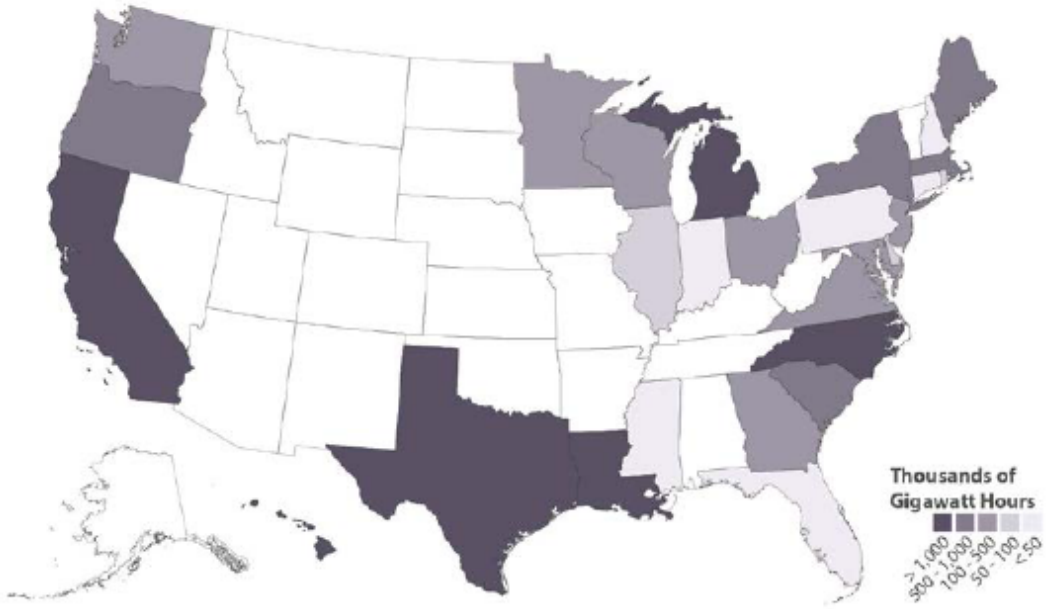


Figure 7. Total estimated technical potential for offshore wind power in the United States

"U.S. Renewable Energy Technical Potentials: A GIS-Based Analysis"
A. Lopez, B. Roberts, D. Heimiller, N. Blair, and G. Porro, NREL/TP-6A20-51946 (July, 2012)

Estimated total potential for enhanced geothermal systems

U.S. Total:	3,976 GW	31,344,696 GWh
Texas:	384 GW	3,030,251 GWh

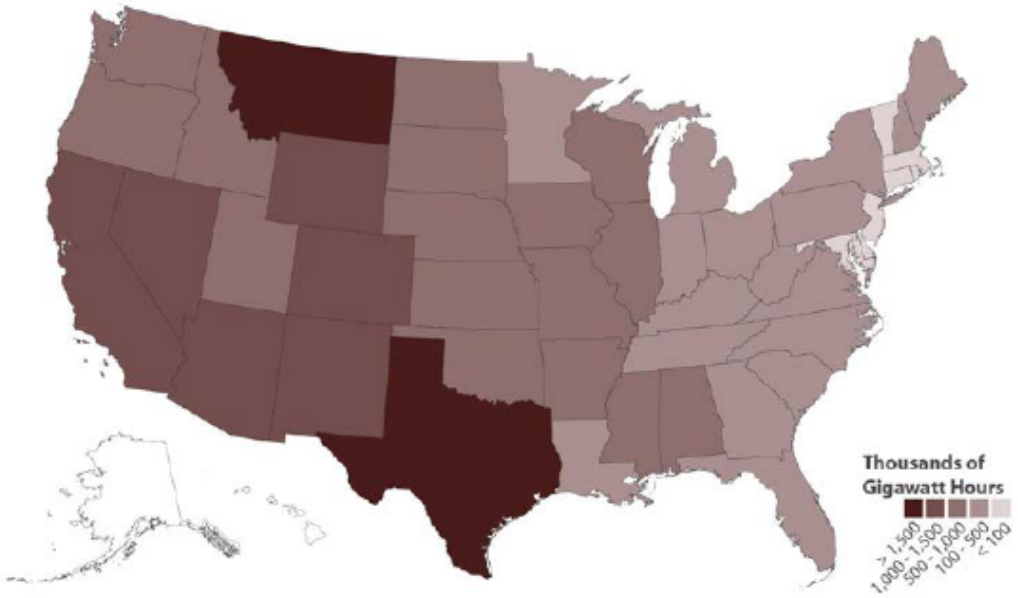


Figure 10. Total estimated technical potential for enhanced geothermal systems in the United States

What's in it for Texas?

Urban utility-scale photovoltaics: Texas has the highest estimated potential (13% of U.S.)

Rural utility-scale photovoltaics: Texas has the highest estimated potential (14% of U.S.)

Rooftop photovoltaics: Texas has the second highest estimated potential

(9% of U.S.)

Concentrating solar power: Texas has the highest estimated potential

(20% of U.S.)

Onshore wind power: Texas has the highest estimated potential

(17% of U.S.)

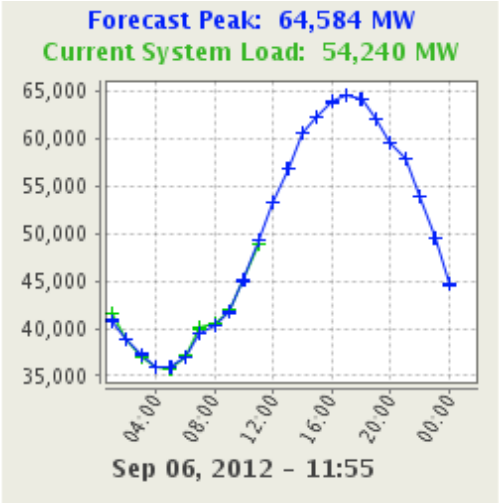
Offshore wind power: Hawaii has the highest estimated potential, while Texas has 6% of U.S.

Enhanced geothermal systems: Texas has the highest estimated potential

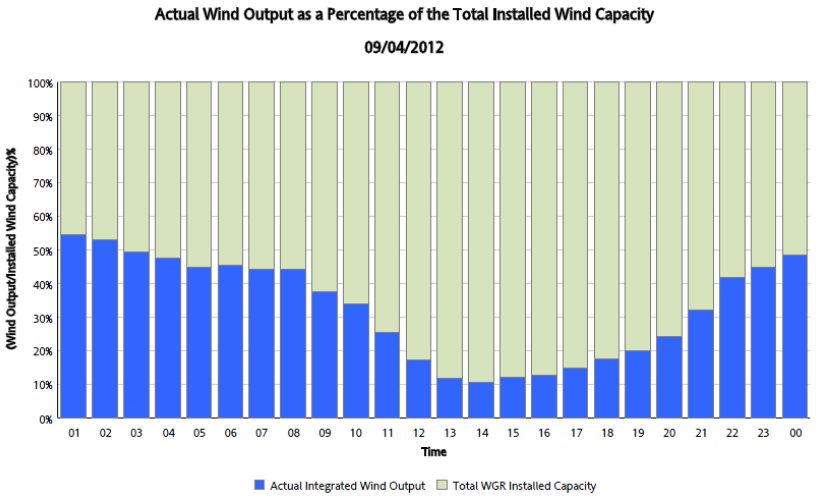
(10% of U.S.)

What's the problem with wind?

When does ERCOT need power?

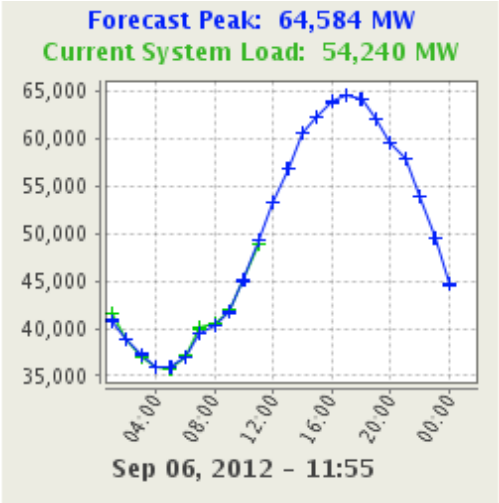


When does the wind blow?

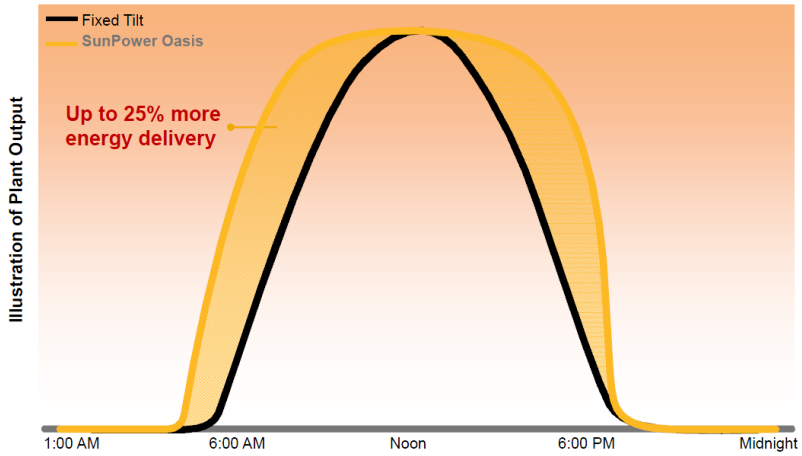


Is there a problem with solar?

When does ERCOT need power?



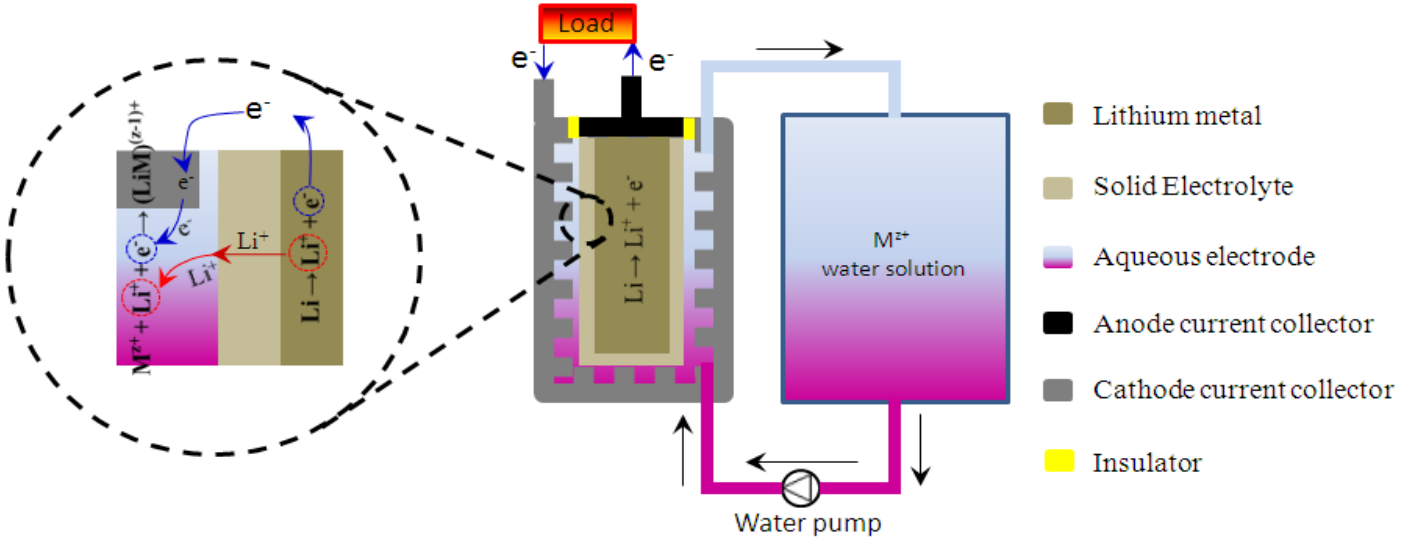
When does the sun shine?



Large-Scale Storage for Intermittent (and even steady) Energy Sources (John B. Goodenough)

- Electricity from wind and solar energy sources is intermittent
  - Wind is strongest when load is least (during summer, wind blows at night, electricity needed during day)
  - Solar intensities vary with time (clouds, dust, and other atmospheric disturbances)
- Even "steady" sources need electrical energy storage
  - Nuclear and coal-fired power plants do not take well to cycling
  - Peaking sources are an expensive luxury, operating only at intermittent times
- "Normal" batteries are ill-suited to base-load storage requirements
- "Flow batteries" offer base-load storage capacity. Requirements for aqueous electrodes:
  - High specific energy density
  - Ambient temperature operation
  - Proper redox potentials
  - No side reactions
  - Good stability in water
  - Good reversibility
  - Reliable safety
  - Low cost

Goodenough, J.B., 2012. Rechargeable batteries: challenges old and new. J. Solid State Electrochem. 16, 2019-2029. http://dx.doi.org/10.107/s 10008-012-1751-2.



Anode reaction: $nA \rightarrow nA^+ + ne^-$; (A=Li or Na)

Cathode Reaction: $M^{z+}(aq) + ne^- \rightarrow M^{(z-n)}+(aq)$;

Overall reaction: $nA + M^{z+}(aq) = nA^+ + M^{(z-n)+}(aq)$; $(1 \leq n < z)$.

- No phase change takes place in the cathode.
- No catalyst is needed in the cathode.
- The cell is rechargeable.
- The cell works at room temperature.
- The cell works in the voltage range of 2.8 to 4.2 V.
- Fe(CN)63-/Fe(CN)64- gives 3.5 V, near 100% coulomb efficiency.

Summary

- Texas is blessed with extraordinary physical and intellectual energy resources.
- Time for a “zoning” for optimum uses of land resources for renewable energy?
  - Sites for wind energy
  - Sites for solar energy
- State investment in base load electrical energy storage research would enhance penetration of renewable energy into ERCOT.
- Opportunities abound for Texas leadership in renewable energy generation.